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ABSTRACT

This study surveyed the degree of comfort expressed by prospective elementary teachers in using inquiry techniques when teaching science. Sixty-six students enrolled in three sections of the Elementary Science Methods course at a university in the northwest United States responded. The general perception expressed by these prospective elementary teachers was that they were unable to use techniques consistent with inquiry science as they were never involved in such processes as students. During their schooling as well as their studies at the university, prospective elementary teachers did not feel they encountered such teaching. This paper concentrates on what science educators can do to support the shift toward inquiry science in the elementary classroom. Inquiry is discussed as a central part of the methods courses. (Contains 11 references.) (ASK)

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by

Hedy Moscovici

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SHIFTING FROM ACTIVITY MANIA TO INQUIRY SCIENCE -- WHAT DO WE (SCIENCE EDUCATORS) NEED TO DO?

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We live in a period of dramatic changes in science education. Research results published in professional journals and books, as well as national documents, call for science to be taught in the same way it builds -- using inquiry. *The National Science Education Standards* express it very clearly: "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (NRC, 1996, p. 31). The document goes beyond general statements and defines the role of the students as the ones who:

> formulate the question and devise ways to answer them, they collect data and decide how to represent it, they organize data to generate knowledge, and they test the reliability of the knowledge they have generated. As they proceed, students explain and justify their work to themselves and to one another, learn to cope with problems such as the limitation of equipment, and react to challenges posed by the teacher and by classmates. Students assess the efficacy of their efforts - they evaluate the data they have collected, re-examining or collecting more if necessary, and making statements about the generalizability of their findings. They plan and make presentations to the rest of the class about their work and accept and react to the constructive criticism of others. (p. 33).

From this paragraph it is evident that inquiry science also provides a natural avenue for integration. Mathematical knowledge (e.g., data collection and representation, testing reliability) and language arts knowledge (e.g., written and verbal communication) add to the quality of the experience.

The teacher's role also requires a move away from the traditional presenter of science. During students' inquiries, teachers are supposed to "guide, focus, challenge, and encourage

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student learning" (NRC, 1996, p. 33). Teachers need to provide help to individual students according to their needs (something that reminds us of the concept of "scaffolding" used by Vygotsky), and promote inquiry by asking questions rather than providing answers.

So, What is the Problem?

I surveyed the degree of comfort expressed by prospective elementary teachers in using inquiry techniques when they teach science. Sixty-six students enrolled in three sections of the Elementary Science Methods course at a university in the northwest United States responded. The general perception expressed by these prospective elementary teachers was that they were unable to use techniques consistent with inquiry science as they were never involved as students in such processes. During their schooling as well as their studies at the university prospective elementary teachers did not feel they encountered such teaching. They also feared that their perceived weak background in science did not support such techniques. If they were going to teach science, they felt more comfortable with a series of disconnected activities or what was called activity mania by Moscovici and Nelson (1998).

Barr (1994) confirms this in her exploration of four main barriers to inquiry science implementation at the elementary level. Her findings show that most teacher preparation programs are inconsistent with inquiry science.

Surveys of practicing elementary teachers uncovered a similar pattern. Samples from two different districts in the Pacific Northwest (Moscovici & Nelson, 1998) show that elementary teachers (N=24) use methods that are consistent with inquiry science only for 22% of their time, and in most cases (based on analysis of descriptions provided by the teachers on the surveys) it was the teacher who went through inquiry rather than the students. In the same surveys, elementary teachers expressed their wish to involve their students in inquiry science at a much higher level and suggested modeling, workshops/courses for inquiry science, and inquiry science support groups as avenues necessary in order to achieve this goal.

Czerniak (1990), found that highly efficacious teachers (teachers who believe that effective teaching will have a positive effect on students' learning) tended to use more inquiry and student-centered teaching strategies while teachers with a low sense of efficacy tended to use more teacher-centered strategies, such as lectures and readings from the textbook. Huinker and Madison's (1997) work suggested that two methods courses (one in science and one in mathematics) that showed consistency in terms of developing efficacious elementary teachers proved successful. The two courses which combined content and fieldwork encouraged the prospective elementary teachers to explore science and mathematics as both learners and teachers. Their results support Barr's (1994) findings mentioned previously and advocate for teacher preparation programs that show consistence with inquiry science.

In this paper I will concentrate on what we (science educators) can do in order to support the shift toward inquiry science in the elementary classroom. We all teach at least one course - the elementary methods in science course - and there are ways to involve prospective teachers in genuine inquiry.

The Science Methods Courses -- Goals

Anderson & Mitchener (1994) described the role of the science methods courses in the following way:

> Science methods courses act as the bridge between many areas of the teacher education curriculum, as well as between education and studies in the science departments. Methods courses help prospective teachers integrate knowledge and gain experience in applying this integrated learning in actual school settings with real students or in simulated environments with peers (p. 17)

During science methods courses, prospective elementary teachers have the opportunity to make their knowledge regarding content and pedagogy explicit, be able to describe their personal teaching philosophy, and become what Schoen called "reflective practitioners" (Schoen, 1987). It is not to say that prospective elementary teachers do not engage in reflection on their experiences as students in science and education classes prior to the science methods course(s). It just says that during the science methods courses reflection is a recommended tool (Nichols, Tippins, and Wieseman, 1997; Abell and Bryan, 1997) to help prospective teachers develop

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content knowledge, pedagogical content knowledge, and curricular knowledge in a variety of forms as suggested by Shulman (1986).

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Inquiry Science as a Central Part of the Methods Courses

The suggestion to have prospective teachers involved in scientific inquiry is not new. I studied more than twenty syllabi for methods courses for elementary teachers in use in different parts of the United States, as well as on different continents. Most of them used elements from the student's role in inquiry science (e.g., collecting data, displaying data, looking for resources), but unfortunately, in a rather disconnected way. I could not find any syllabi that requested students to fulfill all the requirements and go through a full inquiry science unit and have to communicate their findings to peers and/or students.

In the following sections, I will differentiate between two stages in scientific inquiry from the standpoint of the prospective or practicing teacher. One relates to the scientific inquiry that the prospective teacher undergoes as a student in the science methods course (personal inquiry). The other inquiry refers to the scientific explorations performed by students in a classroom where the teacher assumes the role of facilitator helping students with their inquiries.

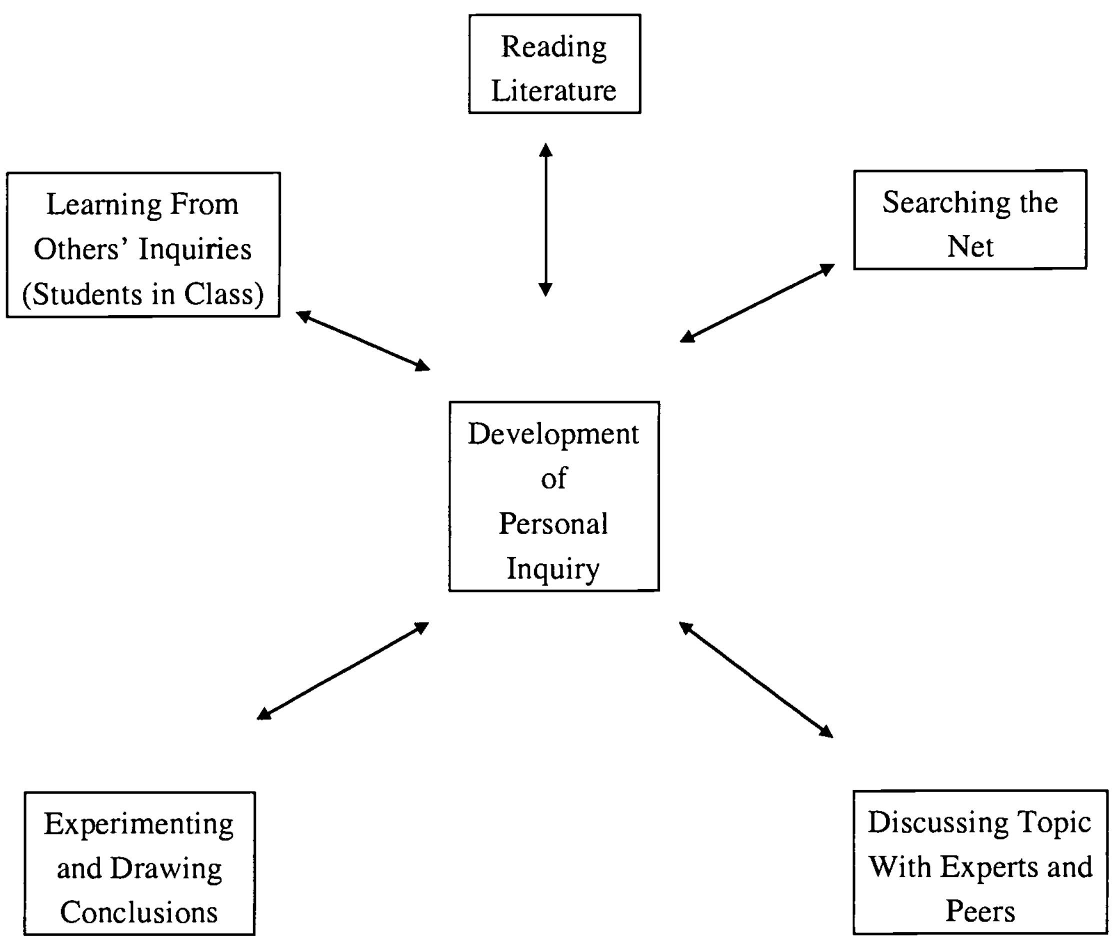
Personal inquiry

This stage of inquiry (see Figure 1) is necessary and it answers to the need expressed by various prospective and practicing teachers: "How can I teach using scientific inquiry if I was never involved in such a process as a student?" It engages the prospective elementary teachers in all the various levels of scientific inquiry stated in the National Science Education Standards in the section regarding the role of the student (NRC, 1996). In many ways this process is the same as the one experienced by every scientist in the research laboratory. From the formulation of the question, to planning and performing experiments, to the formulation and representation of knowledge produced and to the reliability tests, prospective teachers explore personal interests. During their investigations, participants investigate pertinent literature, use educational technology (e.g., Internet, CD-ROMs, video clips) and various experts. Prospective teachers generate knowledge, test for reliability, and justify their results to themselves and to others. Peer presentations and constructive criticism enhance the quality of their inquiries and provide new avenues for research.

Prospective elementary teachers need to reflect during their inquiries and express their feelings during the different stages of inquiry. Such follow-up will prove very valuable when students become teachers trying to involve their own pupils in scientific inquiry.

Figure 1

Essential Elements for the Development of Personal Inquiries



From Personal Inquiry to Involving Students in Inquiry

When the prospective elementary teacher (the student) becomes the teacher, it is important to act as a facilitator, a guide, a provider of scaffolding according to student needs, a follower during students' investigations (NRC, 1996). The shift in roles (from student to teacher, see Table 1) needs to be a reflective one, and the teacher needs to be able to assume a secondary role during student investigations. It is not to say that the teacher cannot use any of their various sources of knowledge (Shulman, 1986) and their experience gathered during personal investigations. Just the opposite. Such situations are excellent integrative experiences in the life of teachers. What I am saying is that they should use their knowledge carefully, only when required for scaffolding. They must not forget that personal scientific inquiry knowledge remains personal, and that it is connected to the person's individual question, experiences, scientific methodology, and theoretical frameworks.

It is not enough for the teacher to have experience as a student in inquiry science in order to have teachers who are going to involve their students in inquiry science. In order to illustrate this statement, I will use the science faculty teaching science courses at the university. Almost all science courses at the university level are taught by scientists with experience as researchers. Their Master of Science, as well as their Ph.D. degrees required scientific research. The problem as I see it is that these researchers teach their personal inquiries (or other researchers' personal inquiries) as "the science that knows" (Latour, 1987, p. 7). It is presented as an established and unquestionable fact that lost its inquiry flavor. Students in these courses do not engage in scientific inquiries and are unable to bring inquiry science into their own classrooms.

The argument brought up in this section reminds me of an argument we had during a session on inquiry science at NARST, 1997. A person in the audience asked "How much science knowledge does a person need to have in order to involve his/her students in inquiry science?" and the answer of the presenter was "None!." I do not think we should go to such an extreme. The teacher must be knowledgeable in various areas of science, education, and curriculum (Shulman, 1986). In addition, he/she must be able to involve students in inquiry science and avoid imposing personal knowledge or other aspects of knowledge of the kind of "the science that knows" (Latour, 1987, p. 7) on the students.

Table 1

Relationships between the kind of experience and roles assumed by the student and teacher.

KIND OF EXPERIENCE	ROLE OF THE STUDENT	ROLE OF THE TEACHER
EXERCISE/ ACTIVITY/ IMPOSED INQUIRY	TECHNICIAN	EXPERT/ CONTROLLER
INQUIRY (NRC, 1996)	DEVELOPS PERSONAL INQUIRIES (RESEARCHER)	FACILITATOR TO CO-LEARNER

Summary

In this paper I raised the argument that as science educators we have the responsibility to accelerate the shift toward inquiry science in the elementary classroom. We have both the knowledge and the support from the *National Science Education Standards* (NRC, 1996) to ensure this kind of shift. While engaged in such a process, prospective elementary teachers have the opportunity to integrate knowledge gained in their science courses with that gained in education courses (Anderson & Mitchener, 1994). They are challenged to interrelate content knowledge (both facts and processes), with pedagogical content knowledge, and with curricular knowledge (Shulman ,1986). They are also encouraged to integrate their knowledge in various subjects, such as mathematics, art, and language arts.

During the elementary science methods courses, science educators are encouraged to engage their students in scientific inquiry much in the same way in which science researchers experience science in their research laboratories. Prospective teachers should become research scientists and experience the various stages of scientific inquiry from the formulation of the research question, to planning and experimenting, testing for reliability and deciding on ways to organize and present their knowledge, to acting according to constructive criticism. This process helps them understand that scientific inquiry is not finite, and that every answer brings more questions and more avenues for research.

Prospective elementary teachers undergoing scientific inquiry need to understand the difference between their personal inquiry process and the experience they need to provide to their students and peers. Through reflection they find ways to avoid transforming their personal inquiry into the "science that knows" (Latour, 1987, p. 7). Inquiry implies helping students find answers to their own questions using principles of scientific inquiry, the "science that does not know yet" (Latour, 1987, p. 7). "The science that does not know yet" (Latour, 1987, p. 7), requires the application of the principles of scientific inquiry to the search for answers to student-generated questions.

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